Module 3 | Lecture 1
Electrochemistry in Diagnostics

Instructor: **Dr. Rajiv K. Kar**

Jyoti and Bhupat Mehta School of Health Sciences and Technology

Indian Institute of Technology Guwahati

Biosensors | Point-of-Care Technology

- Refers to medical technologies that are designed for use near the patient, typically at the patient's bedside, rather than in a laboratory.

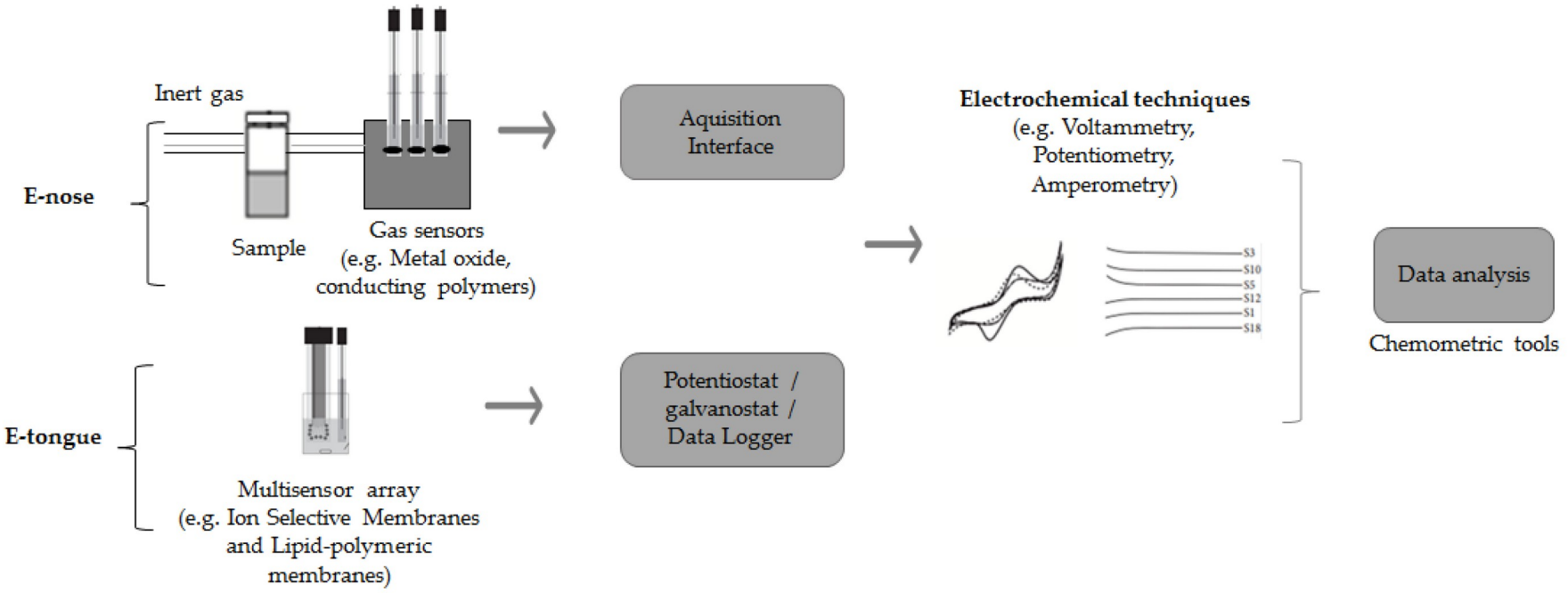
- Key Characteristics:

  Convenience: Portable, compact, and easy to use, enabling healthcare providers to perform tests quickly.

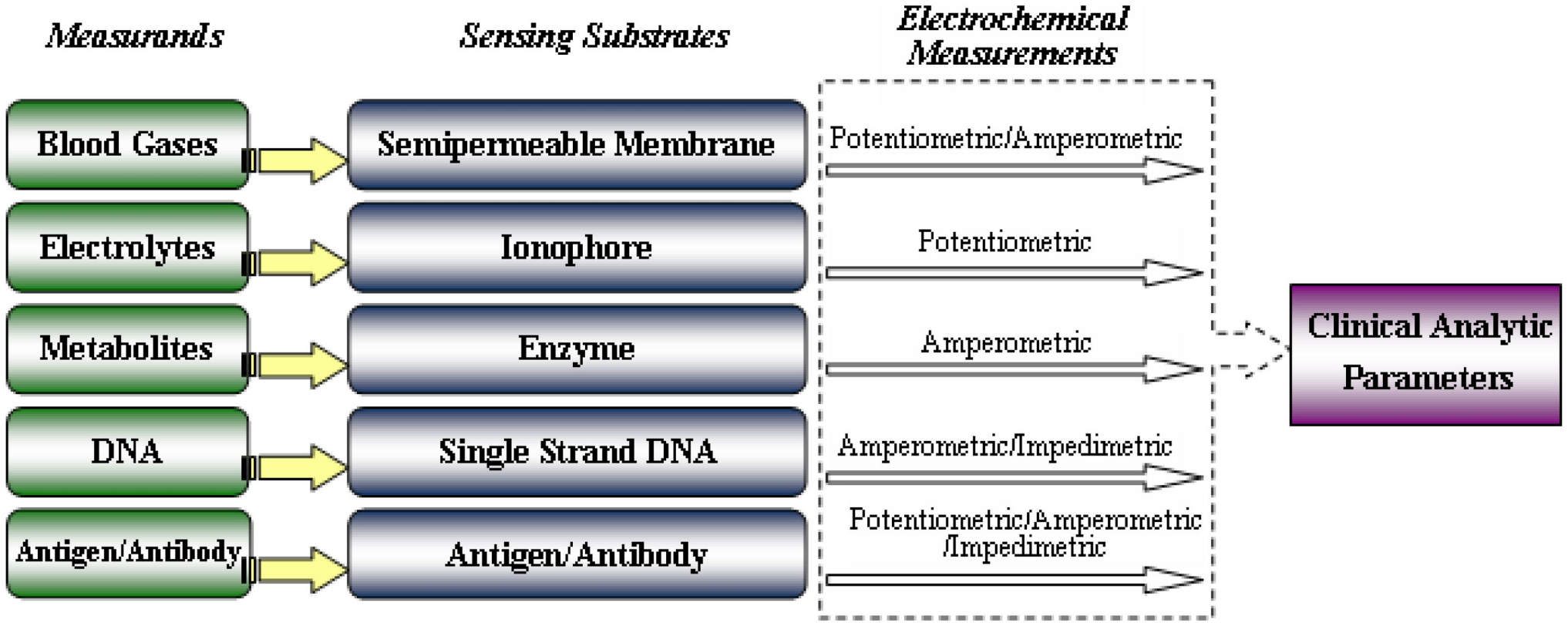
- **Rapid results**: Provide results in minutes or hours.
- **Patient comfort**: Non-invasive or minimally invasive.
- **Increased accessibility**: Allows to perform tests and diagnose conditions in resource-limited settings | Cost effective solution.

Biosensors | Role of Electrodes

- A widely used method for sensing and analyzing | biological and chemical substances.
- An electrical signal is used to probe the presence of a target substance, and the resulting signal is measured and analyzed.



Biosensors | Role of Electrodes

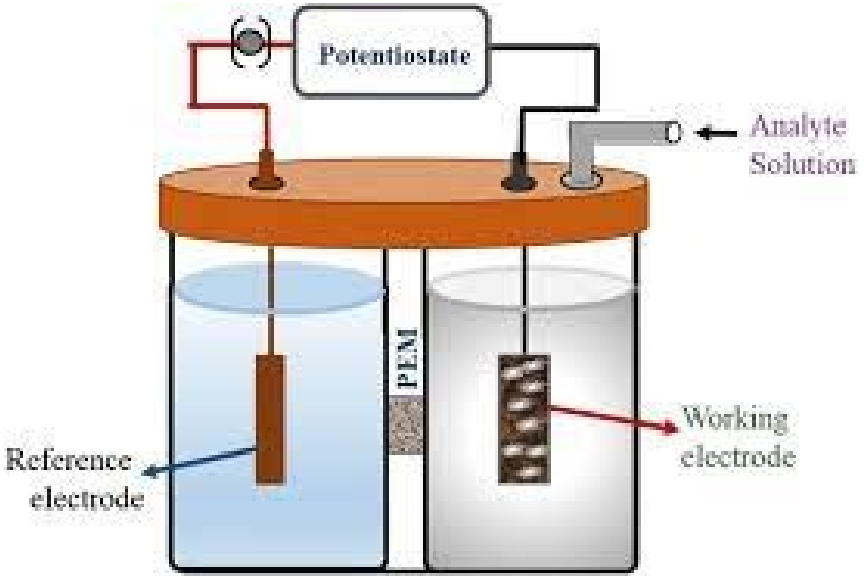


Source: https://doi.org/10.3390/s8042043

Electrochemical Analysis| Potentiometric

Working Principle

- Uses the **electrical potential difference between two electrodes** to determine the concentration of a target substance.
- A **reference electrode** and a **working electrode** are immersed in a solution containing the target substance.
- A **potential is applied** across the electrodes, and the resulting potential difference is measured.
- The **potential difference** is proportional to the **log of the concentration of the target substance**, and the concentration can be determined from the measurement



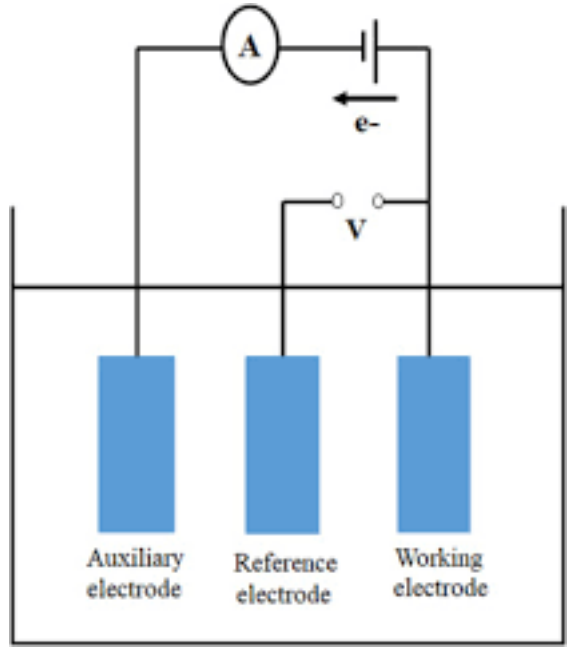
Advantage:

- High accuracy, selectivity, and simplicity.
- Can be easily integrated into compact, portable devices.

Electrochemical Analysis| Amperometry

Working Principle

- It measures the current produced by the **oxidation or reduction** of a target substance at an electrode.
- Consists of working electrode and a reference electrode, which are immersed in a solution containing the target substance.
- Applied potential causes the target substance to **undergo oxidation or reduction at the working electrode.**
- It generates a **current that is proportional to the concentration** of the target substance.
- The current can be measured and used to determine the concentration of the target substance.

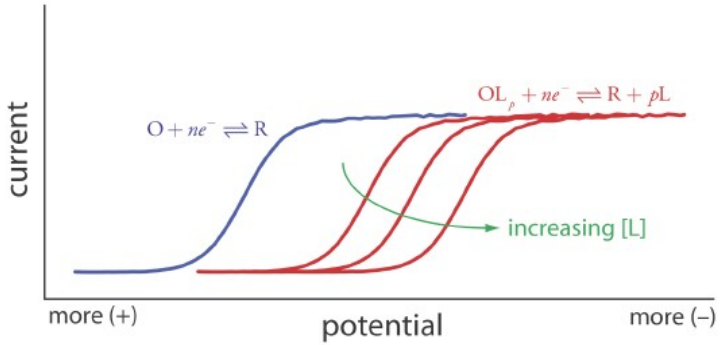


Advantage:

- High sensitivity, rapid response time, and the ability to detect trace amounts of target substances.

Amperometry vs Voltammetry

- **Voltage Ramp**: Voltammetry application of a linear voltage ramp to a working electrode, which is immersed in a sample solution. Leading to repeated oxidation and reduction cycles, generating a current that is proportional to the number of electroactive species.



Amperometry, on the other hand, is characterized by the application of a constant potential to the working electrode.

- **Current Measurement**: Voltammetry measure the current generated as a function of time.

Amperometry measure the current generated by a sample at a single, constant potential.

- **Information Obtained**: Voltammetry -oxidation and reduction potentials of the electroactive species.

Amperometry, rate of electron transfer for a single, specific electrochemical reaction.

- **Sample Characterization**: Voltammetry is more useful for characterizing complex mixtures of electroactive species

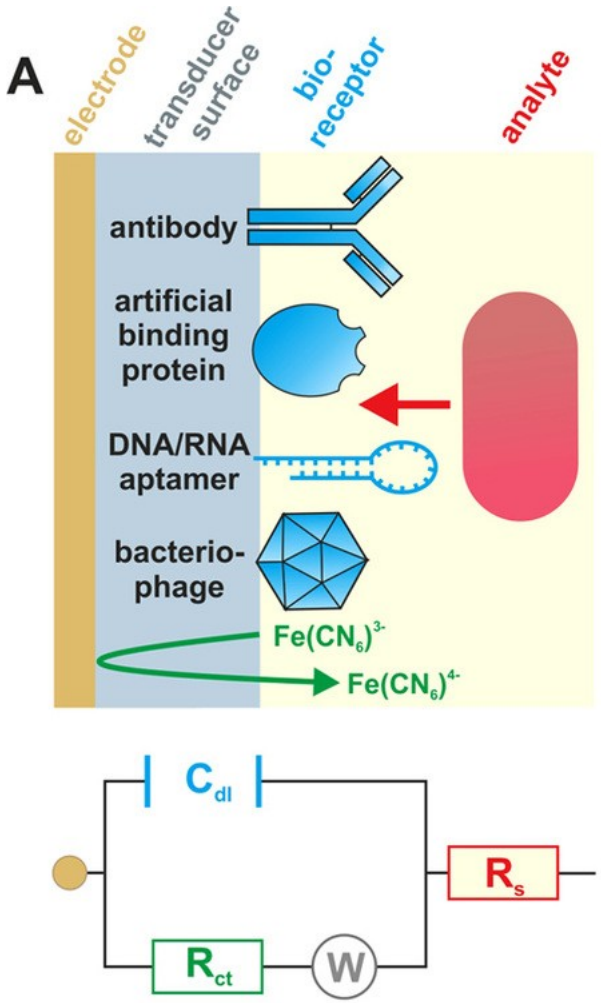
Amperometry is more useful for studying specific, individual electrochemical reactions.

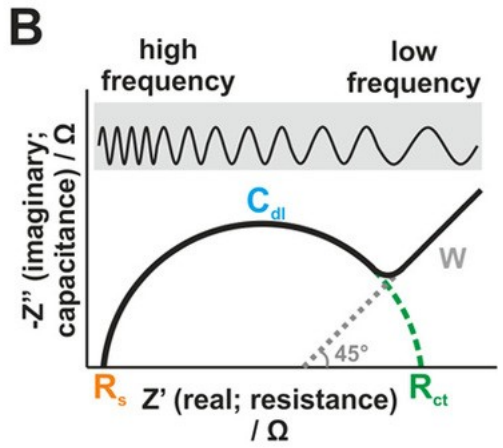
Electrochemical Analysis| Impedimetric

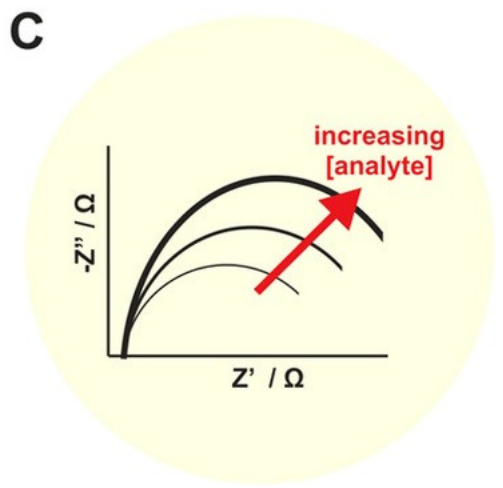
Working Principle

- It measures the impedance (**resistance to the flow of electrical current**) of a system.
- A working electrode and a reference electrode, are immersed in a solution containing the target substance.
- Impedance of the system is determined by **measuring the voltage and current that flow through the electrodes**.

- Impedance of the system is influenced by several factors, including the presence of a target substance, the concentration of the target substance, and the characteristics of the electrodes.







Electrochemistry Fundamental

Working Principle

- **Electrochemistry** - a tool to probe reactions involving electron transfers | flow of electrons to chemical changes.
- In inorganic chemistry, the resulting chemical change is often the oxidation or reduction of a metal complex.
- **Example** - chemical reduction vs electrochemical reduction (reduction of ferrocenium [Fe(Cp)2] + (Cp = cyclopentadienyl), abbreviated as Fc+ , to ferrocene [Fe(Cp)2], abbreviated as Fc)

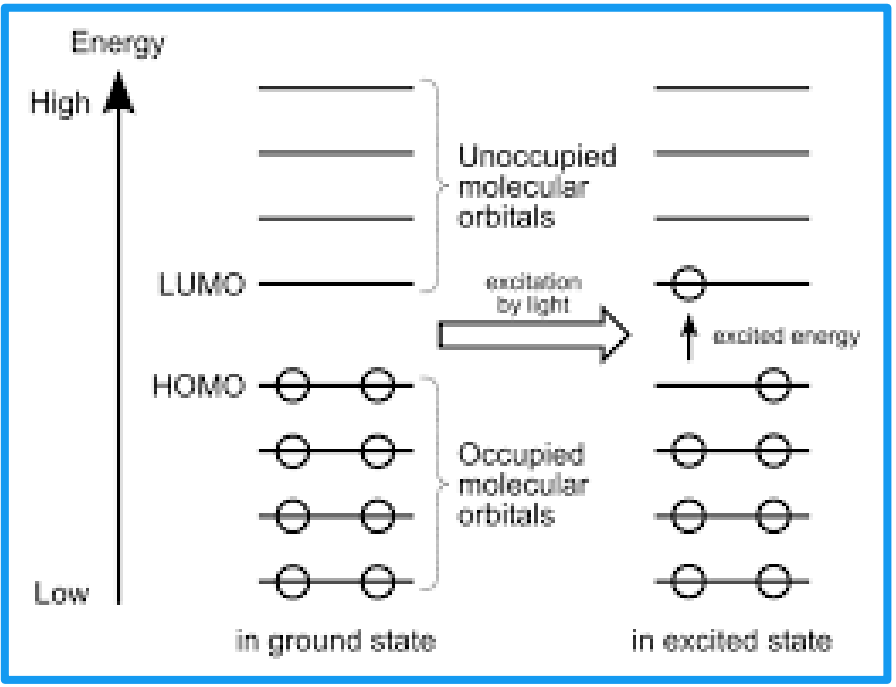
Through a chemical reducing agent

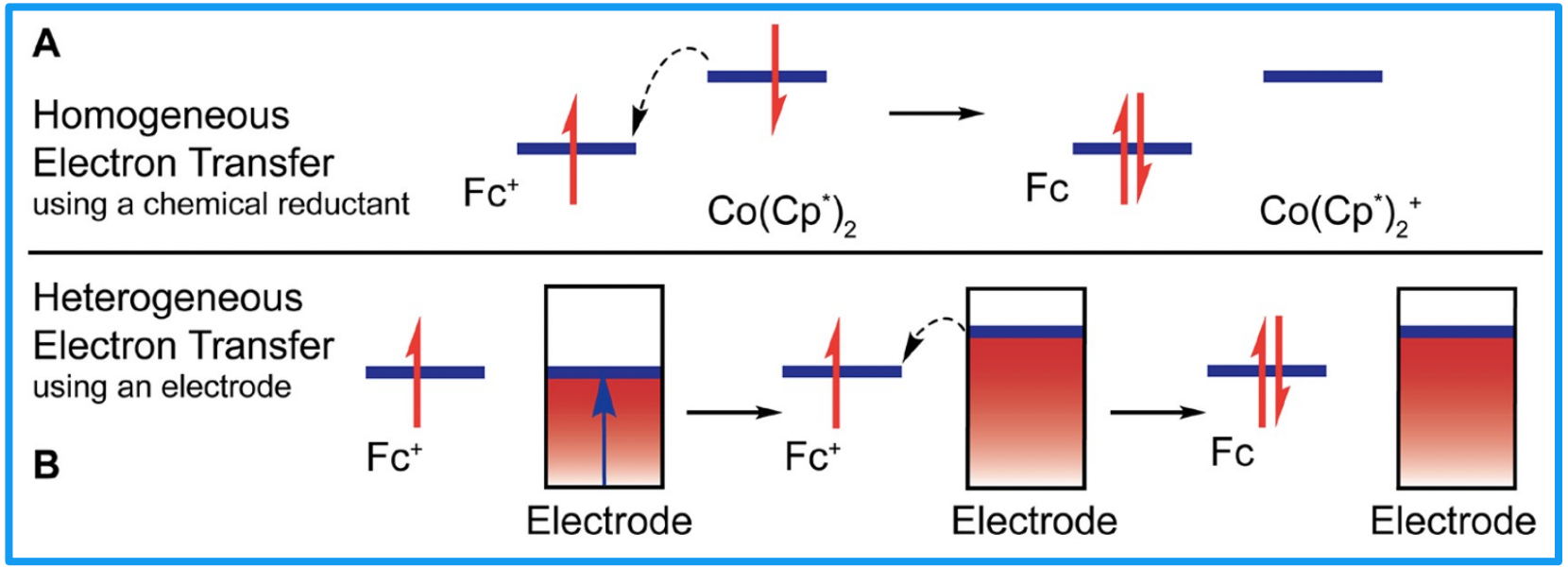
$$Fc^{+} + [Co(Cp^{*})_{2}] \rightleftharpoons Fc + [Co(Cp^{*})_{2}]^{+}$$

At an electrode

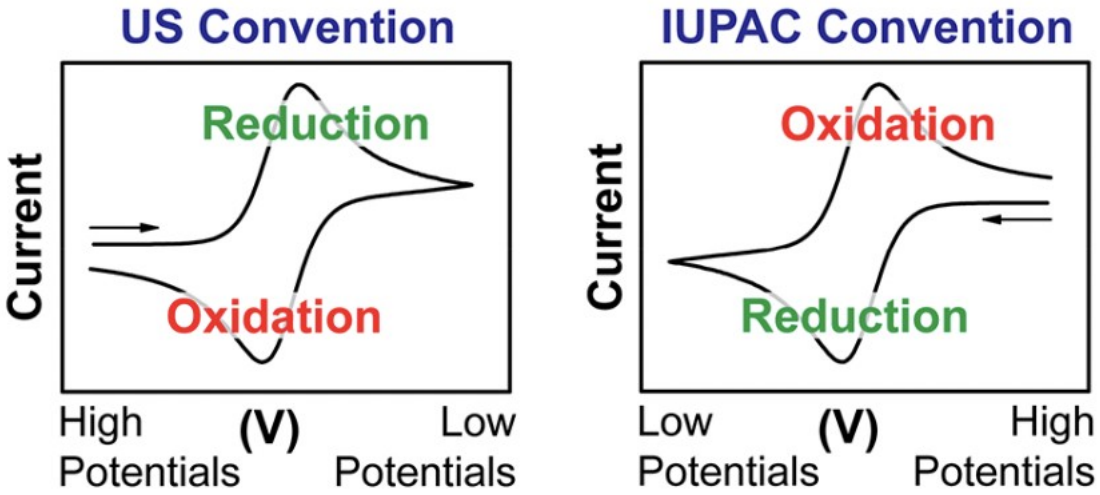
Source: http://dx.doi.org/10.1021/acs.jchemed.7b00

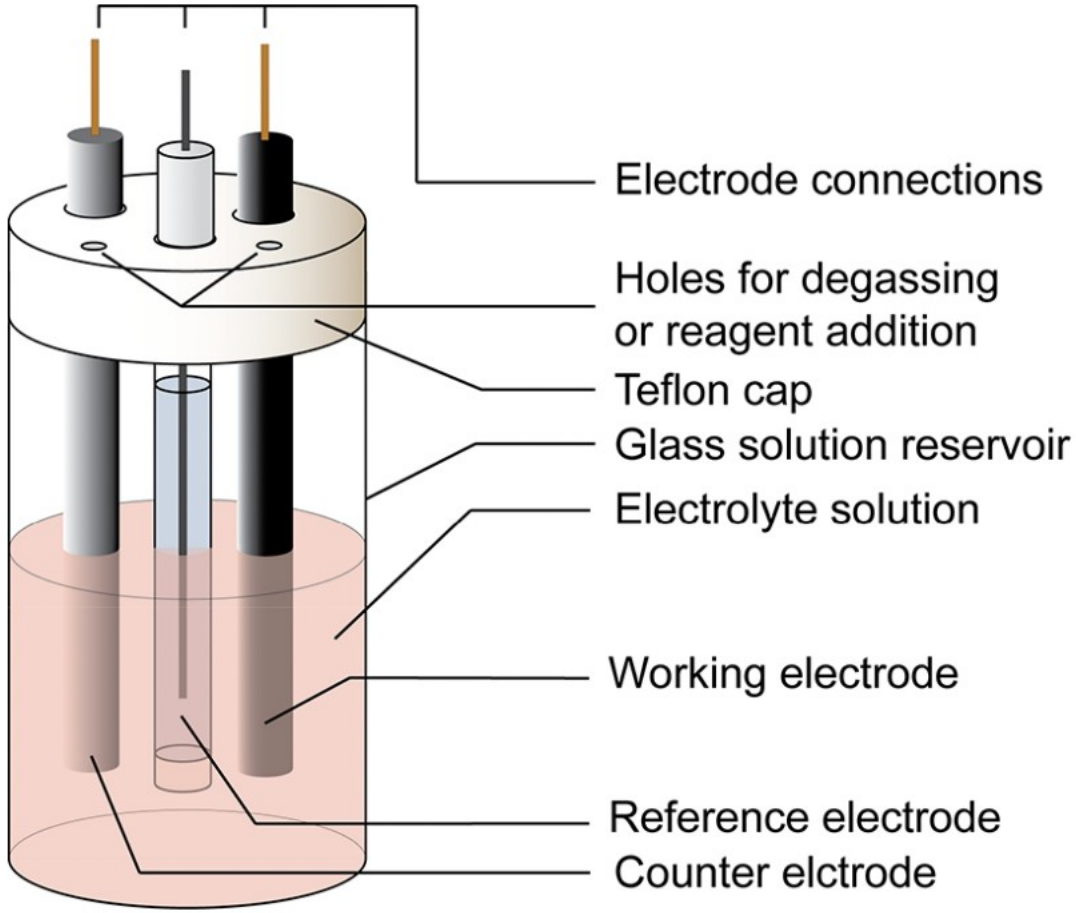
Electrochemistry Fundamental | Graphics





Cyclic Voltammetrv





Working Principle

- The x-axis represents applied potentia (E) and y-axis is the response i.e. curr (i) passed.
- The arrow indicates the beginning and sweep direction of the first segment (or "forward scan").

Source: http://dx.doi.org/10.1021/acs.jchemed.7b00

Next in the class

Cell Potential

SHE

Nernst Equation